MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

PPH0125 – MECHANICS

(Foundation in Engineering)

16 OCTOBER 2018
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 5 pages excluding the cover page and the appendices with **FIVE** questions only.
2. Attempt **ALL** questions. Distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings must be shown.

Answer **ALL** questions.

Question 1: [10 marks]

a) Figure Q1a shows a system of two objects connected by a rope of negligible mass. If the coefficient of friction between the 4.0 kg block and the surface is 0.5 and the system starts from rest, determine the speed of the 8.0 kg ball just before it hits the floor.

(5 marks)

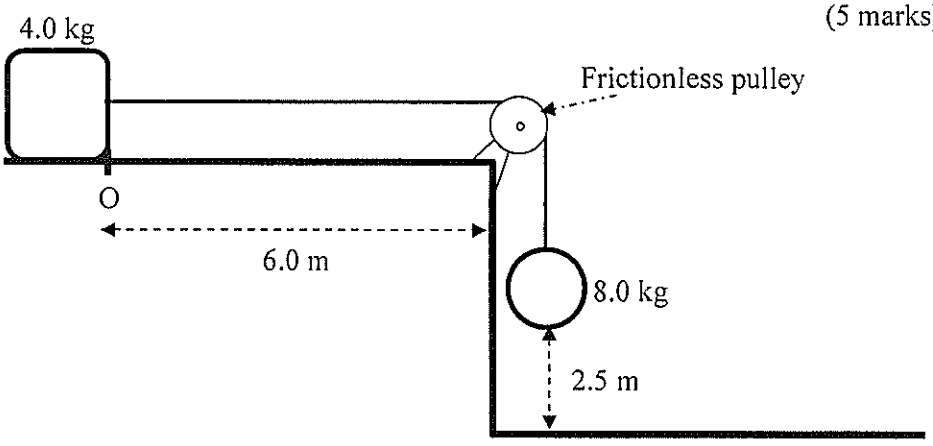

Figure Q1a

b) Determine the magnitudes of the forces, F_A and F_B, exerted on the beam by the two supports at its end as shown in Figure Q1b.

(5 marks)

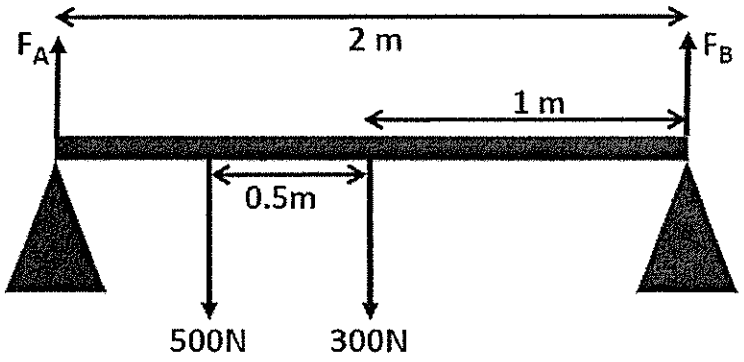

Figure Q1b

Continued...

Question 2: [10 marks]

a) An object of mass 500 g moves in a uniform circular path of radius 2 m at the speed of 6 m/s as shown in Figure Q2a.

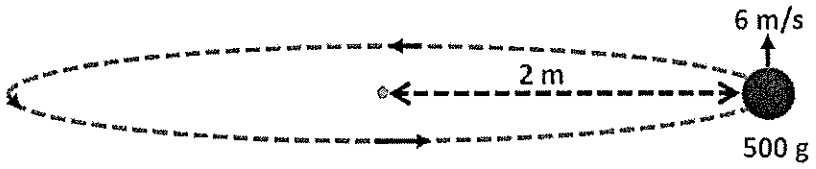

Figure Q2a

i) Calculate the force acting on the object that maintains its circular motion.
(1 mark)

ii) Determine the centripetal acceleration of the object.
(1 mark)

iii) What is the time taken by the object to make one complete rotation?
(1 mark)

b) Figure Q2b shows a system of four small objects, all having the same mass of 500 g and rotating on horizontal surface at an angular velocity of 5 rad/s. The objects are connected by light, flexible spokes that can be lengthened or shortened. Determine the value of the angular velocity if all the four spokes are shortened from 100 cm to 25 cm.
(4 marks)

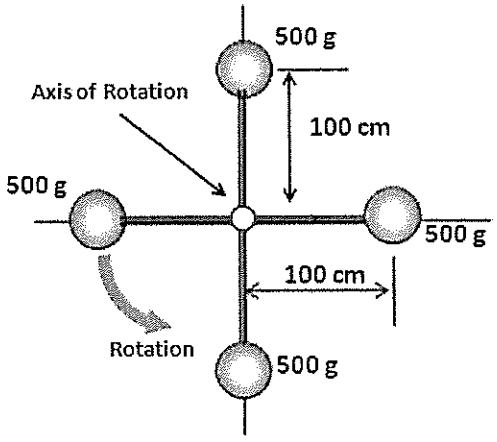

Figure Q2b

Continued...

c) Figure Q2c shows a rotor. If it is rotated from rest to 30,000 revolutions per minute (rpm) in 20 seconds, determine the angular acceleration, α, of the rotor.

(3 marks)

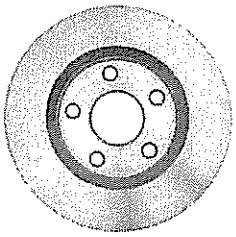

Figure Q2c

Question 3: [10 marks]

A new satellite of mass 1000 kg is launched into an orbit at 2000 km above Earth's surface and moves at a constant speed around the earth in a circular orbit as shown in Figure Q3.

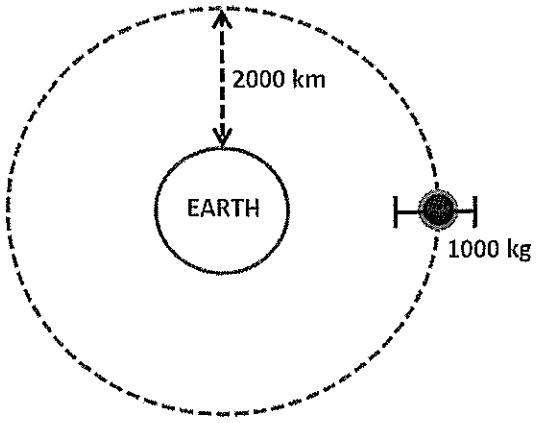

Figure Q3

a) What is the magnitude of the force between the Earth and the satellite?

(2 marks)

b) What is the satellite's speed in the orbit?

(2 marks)

c) How much time does the satellite take to make one complete revolution?

(2 marks)

d) What is the gravitational potential energy of the Satellite-Earth system?

(2 marks)

e) What is the total energy of the satellite?

(2 marks)

Continued...

Question 4: [10 marks]

a) Two ends *A* and *B* of a wire of length 2 m and diameter 2 mm fixed to the walls so that the wire is horizintal and unstretched, as shown in Figure Q4a. An object is then suspended at the midpoint, *C*. Finally, point *C* settles down at a point 2 cm below its initial position. Determine the mass, *M*, of the object. ($Y_{wire} = 9.0 \times 10^{10}$ N/m^2)

(5 marks)

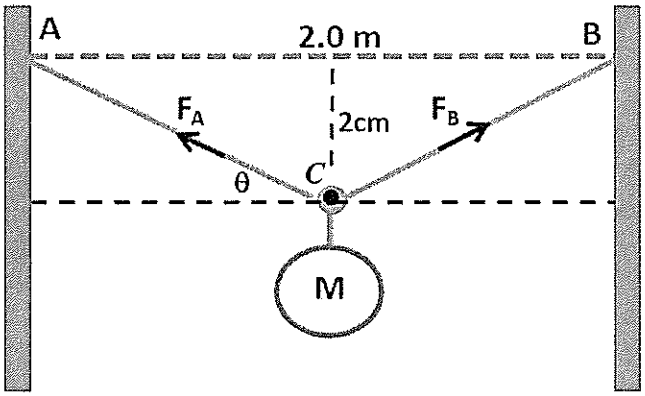

Figure Q4a

b) Figure Q4b shows the extension force graph for the steel wire. Explain what happened to the steel wire at point *A*, *C* and *E*.

(5 marks)

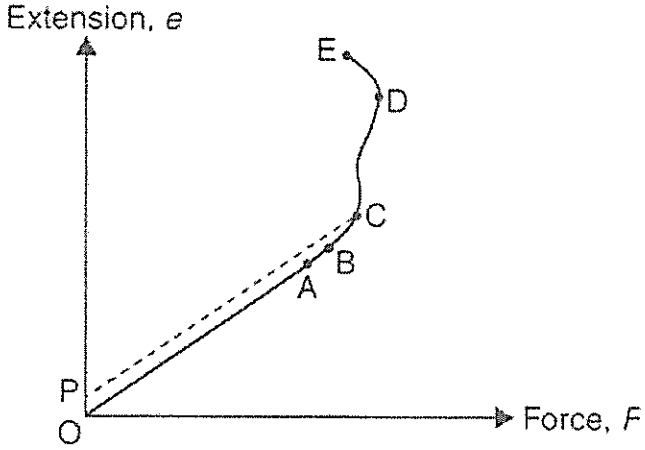

Figure Q4b

Continued...

Question 5: [10 marks]

Figure Q5 shows a spring of negligible mass stretches 2.00 cm from its relaxed length when a force of 10.0 N is applied. A 0.40 kg object rests on a frictionless horizontal surface and is attached to the free end of the spring. The object is pulled horizontally so that it stretches the spring 12.00 cm and is released from rest at time $t = 0$ s.

a) Determine the amplitude, A, of the motion.

(1 mark)

b) Determine the spring constant, k.

(1 mark)

c) Obtain angular frequency, ω, of the system.

(1 mark)

d) What is the maximum speed achieved by the object once it is released from rest?

(1 mark)

e) At which position does the object achieve its maximum speed as in (d)?

(1 mark)

f) Calculate the maximum acceleration of the system.

(1 mark)

g) Obtain period, T, for this motion.

(1 mark)

h) Write the expression for the displacement of the mass.

(1 mark)

i) Determine the speed of the mass when it is at position $x = 0.07$ m.

(2 marks)

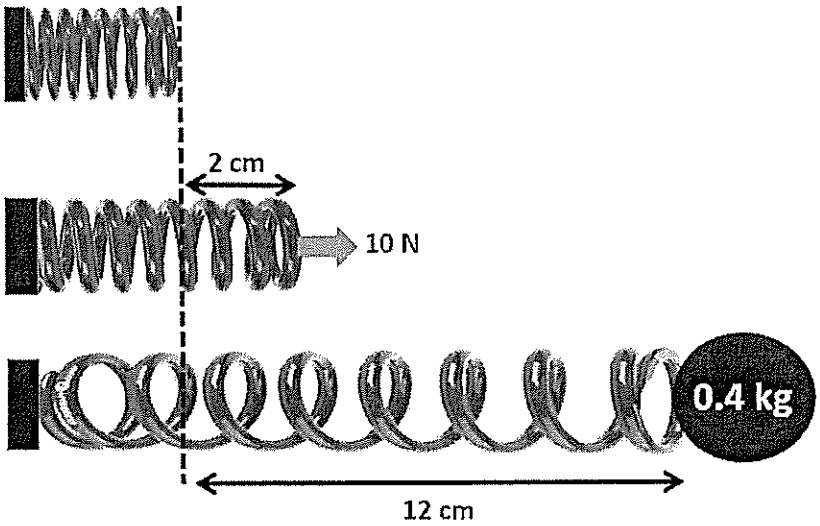

Figure Q5

End of Paper

APPENDIX I

Physical Constants

Quantity	Symbol	Value
Electron mass	m_e	9.11×10^{-31} kg
Proton mass,	m_p	1.67×10^{-27} kg
Elementary charge	e	1.602×10^{-19} C
Gravitational constant	G	6.67×10^{-11} N.m^2 /kg^2
Gas constant	R	8.314 J/K.mol
Hydrogen ground state	E_0	-13.6 eV
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Compton wavelength	λ_c	2.426×10^{-12} m
Planck's constant	h	6.626×10^{-34} J.s
Speed of light in vacuum	c	3.0×10^8 m/s
Rydberg constant	R_H	1.097×10^7 m^{-1}
Acceleration due to gravity,	g	9.81 m /s^2
Atomic mass unit (1u)	u	1.66×10^{-27} kg
Avogadro's number	N_A	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing	I_0	1.0×10^{-12} W /m^2
Coulomb constant	k	8.988×10^9 N m^2 /C^2
Permittivity of free space	ε_0/κ_0	8.85×10^{-12} C^2/N.m^2
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ H/m

Energy equivalent of atomic mass unit:

One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

Earth:

Gravity	=	9.81 m s^{-2}
Radius	=	6.38×10^6 m
Mass	=	5.98×10^{24} kg

Moon:

Mass	=	7.35×10^{22} kg
Radius	=	1.74×10^6 m

Sun:

Mass	=	1.99×10^{30} kg
Radius	=	6.96×10^8 m

Mean distance from:

Sun to Earth	=	1.50×10^{11} m
Moon to Earth	=	3.85×10^8 m

APPENDIX II

List of Formulas

$$y = kx^n \qquad \frac{dy}{dx} = knx^{n-1}$$

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}} \qquad \cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} \qquad \tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

$$\sin\alpha + \sin\beta = 2\cos\left(\frac{\alpha-\beta}{2}\right)\sin\left(\frac{\alpha+\beta}{2}\right)$$

$$\sin(\alpha-\beta) + \sin(\alpha+\beta) = 2\sin\alpha\cos\beta$$

$$v = v_o + gt \qquad y - y_o = v_o t + \frac{1}{2}gt^2 \qquad v^2 = v_o^2 + 2g(y - y_o) \qquad y - y_o = \left(\frac{v_o + v}{2}\right)t$$

$$a_c = \frac{v^2}{r} \qquad F_g = G\frac{m_1 m_2}{r^2} \qquad U_g = -G\frac{m_1 m_2}{r} \qquad T^2 = K_s r^3$$

$$\tau = r \times F \qquad \sum\tau = \tau_{net} = I\alpha \qquad I = \sum mr^2 \qquad v = r\omega$$

$$L = r \times p = I\omega \qquad K = \frac{1}{2}I\omega^2 \qquad |\tau| = |r||F|\sin\theta$$

$$T_s = 2\pi\sqrt{\frac{m}{k}} \qquad T_p = 2\pi\sqrt{\frac{l}{g}} \qquad T = \frac{2\pi}{\omega} = \frac{1}{f} \qquad \bar{y} = \frac{\sum_{i=1}^{N} m_i y_i}{\sum_{i=1}^{N} m_i}$$

$$x = A\cos\omega t \qquad x = A\sin\omega t$$

$$v = -\omega A\sin\omega t \qquad v = \omega A\cos\omega t \qquad W_F = |r||F|\cos\theta$$

$$a = -\omega^2 A\cos\omega t \qquad a = -\omega^2 A\sin\omega t$$

$$v = \frac{\Delta x}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t}$$

$$v = v_o + at \qquad x - x_o = v_o t + \frac{1}{2}at^2 \qquad v^2 = v_o^2 + 2a(x - x_o) \qquad x - x_o = \left(\frac{v_o + v}{2}\right)t$$

$$W = mg \qquad \sum F = F_{net} = ma \qquad f_s \le \mu_S F_N \qquad f_k = \mu_K F_N$$

$$p = mv \qquad \sum F = \frac{\Delta p}{\Delta t} \qquad \Sigma W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \qquad m_1u_1 + m_2u_2 = (m_1 + m_2)v \qquad P = \frac{W}{t} = \frac{E}{t} = \frac{Fd}{t} = F\bar{v}$$

$$K = \frac{1}{2}mv^2 \qquad PE_s = \frac{1}{2}kx^2 \qquad F_s = -kx \qquad PE_G = mgy$$

$$\bar{x} = \frac{\sum_{i=1}^{N} m_i x_i}{\sum_{i=1}^{N} m_i} \qquad W_{fs} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$$